LEVEES DOWNSTREAM OF SACRAMENTO BYPASS HYDRAULIC MITIGATION DESIGNS

Table of Contents

1.0 Introduction.

Geotechnical levee improvements are recommended based on the hydraulic mitigation results developed by the Hydraulics Section. The mitigation results represent increases in the PNP elevation while maintaining the existing PFP elevation or chance of failure. The PNP mitigation areas are shown in Figure 1.1 and those reaches that required a change are labeled 1R, 1L, and 3.

2.0 Hydraulic Mitigation Area Fixes.

a. Index Area 1R.

Explorations consisted of the following cone penetrometer tests (CPTs); CPT-1 through CPT-21 which were located on the right (west) bank of the Yolo Bypass and were spaced at 3000 feet from approximate river miles 50 to 38.9. CPT-1 through CPT-14 occurred upstream of Willow Slough, CPT-15 occurred along Willow Slough – left bank, CPT-16 through CPT-20 occurred between Willow Slough and Putah Creek, and CPT-21 occurred along Putah Creek – left bank. A plan view of the locations of the CPTs can be seen in Figures 2.1 and 2.2.

Critical reaches were examined based mainly on the results of the CPT explorations and typical geotechnical failure scenarios. The explorations for CPT-2, CPT-6, and CPT-10 along the west bank of the Yolo Bypass show potential for underseepage problems due to sand layers below the levee in the foundation. The top of the sand layers for CPT-2 and CPT-6 occur at an approximate depth of 20 feet below the landside levee toe. The change in hydraulic head for the levee sections at CPT-2 and CPT-6 is approximately equal to 10 feet. Although the levee sections at CPT-2 and CPT-6 would not pose a significant threat to underseepage failures, the threat level could be considered medium.

The top of the sand layer for CPT-10 occurs at an approximate depth of 13 feet below the landside levee toe. The change in hydraulic head for the levee section at CPT-10 is approximately equal to 13 feet. The levee section at CPT-10 poses a significant threat to underseepage failures. The underseepage potential (graphical analysis) profile is shown in Figure 2.4.

These three areas, those governed by CPT-2, 6, and 10, would most likely lead to the lowest PFP/PNP combinations for this reach (index area) due to their underseepage failure potential. Slope stability type of failures probably do not dominate the analysis since the levees are made of firm to stiff clays. Since the sands layers are bounded (top and bottom) by impervious layers and they are not too deep, slurry walls (soil-cement-bentonite) are the ideal fix for these situations. CPTs were conducted 3000 feet upstream and downstream of the suspect explorations (see Figure 2.4) and no sand layers were found in the foundation. Therefore, it is conservatively estimated that the length of the slurry walls at these three locations would be at the most 6000 feet each. Details of the slurry wall for cost estimating purposes are shown in Table 1.

Table 1. Recommended Fixes for Index Area 1R

Midpoint of Wall [a] (River Mile)	Slurry Wall (width = 3 feet)	
	Depth [b] (feet)	Length (feet)
49.4	60	6000
47.2	60	6000
44.9	40	6000

[a] for example, wall extends 3000' upstream and 3000' downstream of midpoint
[b] from levee crest

b. Index Area 3.

Explorations consisted of the following cone penetrometer tests (CPTs); Yolo Bypass – west (right) bank – approximate river miles 30 to 21.5 – CPT-22 through CPT-35 from the beginning of the levee at Libfarm downstream along Shaq Slough to the confluence of Cache Slough. The locations of the CPTs can be seen in Figure 2.3.

Critical reaches were examined based mainly on the results of the CPT explorations and typical geotechnical failure scenarios. Using the same method of analysis for index area 1R, underseepage potential failures should be examined for CPTs 22, 23, 24, 27, 33, and 35.

The levees in the upper reach are short and the change in hydraulic head across these sections is very small. Due the small head difference, the potential for underseepage failures is minor to none; this situation occurs for CPT explorations 22, 23, and 24.

The change in head for CPT-27 is comparatively small and the depth to the sand layer from the landside toe (thickness of top stratum) is approximately equal to 33 feet. Thus the potential for underseepage failures is minor to none.

On the other hand, the change in head for the sections at CPT-33 and CPT-35 is relatively large and the thickness of the top stratum is approximately equal to 35 and 25 feet, respectively. The potential for underseepage failures would not be considered significant but could be considered a medium level of threat. This reach would most definitely have the largest effect on the PFP/PNP combinations. The sand layers are bounded (top and bottom) by impervious layers and a slurry wall type of fix would work well. The details of the slurry wall (soil-cement-bentonite) for cost estimating purposes are shown in Table 2. The underseepage potential (graphical analysis) profile is shown in Figure 2.5.

The levees are constructed of firm to stiff clays and slope stability failures should not control or be a significant portion of the risk-based failure analysis.

Table 2. Recommended Slurry Wall Fixes for Index Area 3

Midpoint of Wall [a] (River Mile)	Slurry Wall (width = 3 feet)	
	Depth [b] (feet)	Length (feet)
23.3	60	6000
22.1	70	6000

[a] for example, wall extends 3000' upstream and 3000' downstream of midpoint
[b] from crest

In order to raise the PNP to the magnitudes determined by hydraulics, those areas identified in the Sacramento River Flood Control System Evaluation for the Lower Sacramento River Area Phase IV studies, February 1993, should be implemented. Only those that are located within the hydraulically impacted areas of this study are recommended. These areas are outlined and summarized in the following paragraphs.

Also, the problem areas identified in the Phase IV study of the Lower Sacramento River Area, Supplemental Basis of Design, August 2000, should be repaired to raise the PNP. The landside repairs that are part of the hydraulic mitigation areas are shown in Tables 3 and 4 with cross-sections shown in Figures 2.6 and 2.7.

Table 3. Repairs Recommended as Part of the Phase IV Study – August 2000 Report

River or Slough	Site #	LM/ Bank	Failure Condition	Recommended Fix
Steamboat	501-00-1	1.62/ Right	Boils	Seepage/Stability Berm (Alt. B - 45' Wide x 2500' Long)
Sutter	349-00-1	2.39/ Left	Boils & Seepage	Stability Berm/ Toe French Drain (Alt. C - 25' Wide x 600' Long) & (Alt. C1 - 25' Wide x 730' Long)
Steamboat	3-00-1	3.1/ Left	Slumping	Seepage/Stability Berm (Alt. D - 12' Wide x 1500' Long)
Sacramento	3-00-6	8.09- 8.15/ Right	Boils	Seepage/Stability Berm (Alt. D - 12' Wide x 1000' Long)

Table 4. Repairs Recommended as Part of the Phase IV Study – February 1993 Report

River or Slough	Site #	1993 Report Figure/Bank	Failure Condition	Recommended Fix
Sutter	349-1	Fig 4 / Left	Boils	Stability Berm (Alt. C - 25' Wide x 1500' Long)
Steamboat	501-8	Fig 4 / Right	Boils & Seepage	Stability Berm/ Toe French Drain (Alt. B - 45' Wide x 2000' Long)
Steamboat	501-9	Fig 4 / Right	Slumping	Seepage/Stability Berm (Alt. B - 45' Wide x 2500' Long)
Steamboat	3-2	Fig 4 / Left	Stability	Stability Berm (Alt. D - 12' Wide x 8000' Long)
Steamboat	3-3	Fig 4 / Left	Seepage	Seepage Berm (Alt. C – 25' Wide x 300' Long)
Cache	501-1A	Fig 4 / Left	Stab/Seep	Stab/Seep Berm (Alt. B – 45' Wide x 1200' Long)
Cache	2098-10	Fig 4 / Left	Stab	Stab Berm (Alt D – 12' Wide x 2500' Long)
Cache	2098-10A	Fig 4 / Left	Stab/Seep	Stab/Seep Berm (Alt C-1 – 25' Wide x 400' Long)
Yolo Bypass	2068-1	Fig 3 / Right	Stab	Stab Bern (Alt D – 12' Wide x 2500' Long)
Yolo Bypass	2068-2	Fig 3 / Right	Stab	Stab Berm (Alt D – 12' Wide x 10,000' Long)

c. Index Area 1L.

In order to raise the PNP to the magnitudes determined by hydraulics, those areas identified in the "Sacramento River Flood Control Project, Mid-Valley Area, Phase III, June 1996," should be implemented. The levee improvements involve lime treatment of the upper 4 feet of the crown and the landside levee slopes as shown in Figure 2.8. The length of the levee improvements amount to approximately 6 miles along the left bank of the Yolo Bypass from I-5 downstream to the north end of the Sacramento bypass. A plan view of the treatment locations can be seen, in this document, on Plate 3-6 of "Chapter E. Civil Design."

PreProject Condition
1999 Economic Pre Project
Project Condition
145-180 Step w/Pre Release
With Widened Sacramento Weir

Index Area/Reach	Description	PNP Increase (ft)
1R	Right Bank Yolo Bypass and Willow Slough Bypass	0.6
1L	Left Bank Yolo Bypass	1.0
2	Sacramento River above American River	0
3	Lower Yolo Bypass, Lower Sacramento River and Sloughs	0.3
5	Cross Canal	0

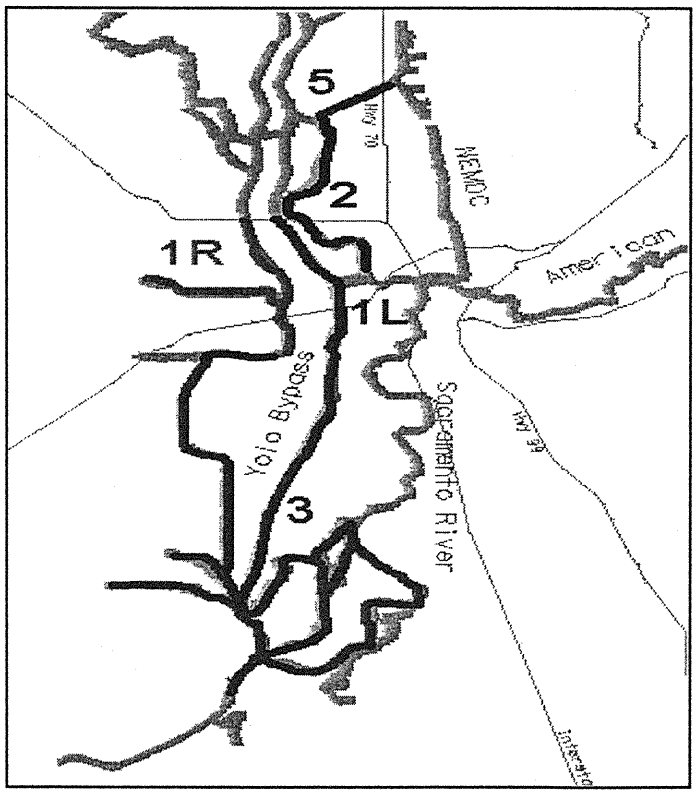


Figure 1.1. PNP MITIGATION AREAS and AMOUNTS

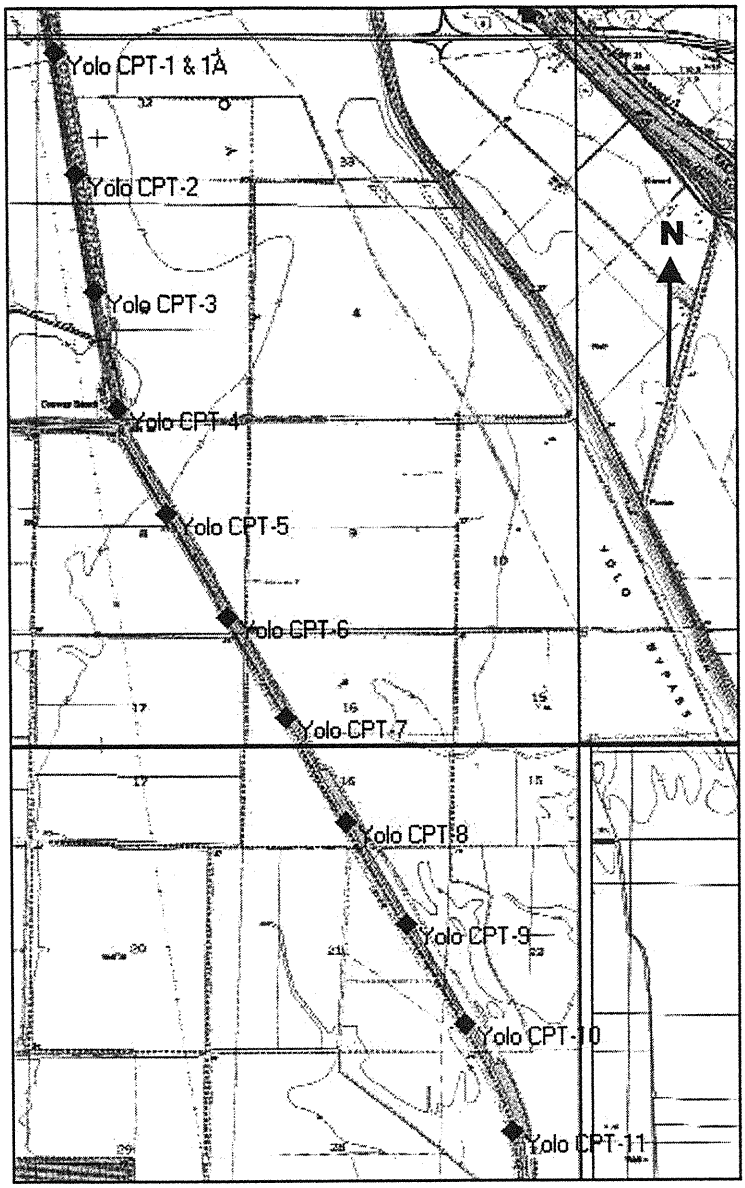


Figure 2.1 Plan View of CPTs 1 through 11 – Yolo Bypass
(See Figure 2.3 for location coordinates)
[USGS QUADS: Grays Bend (NW), Davis (SW), Sacramento West (SE), Taylor Monument (NE)]

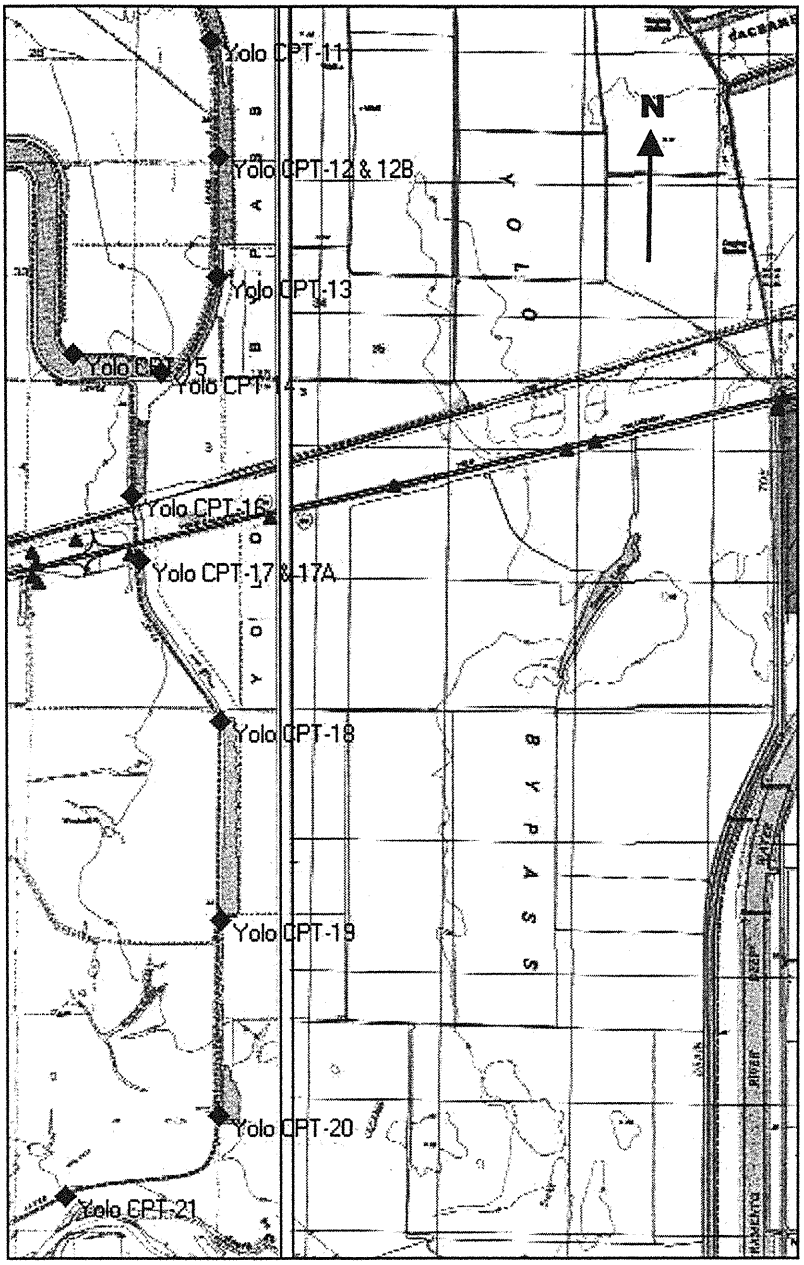
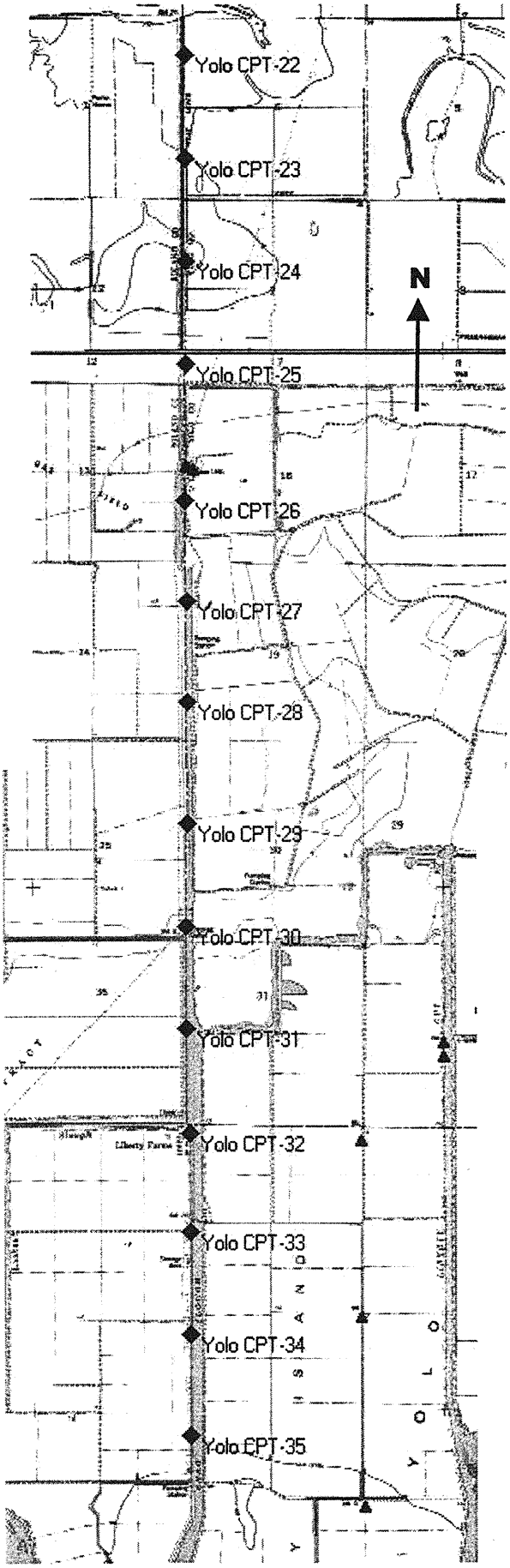


Figure 2.2 Plan View of CPTs 11 through 21 – Yolo Bypass
(See Figure 2.3 for location coordinates)
[USGS QUADS: Davis (W), Sacramento West (E)



	UTM Coordinates (ft) (NAD 83)	
	38 N	121 W
CPT-1	40 21.13	40 18.27
CPT-2	39 51.82	40 12.37
CPT-3	39 21.95	40 06.54
CPT-4	38 53.23	39 59.58
CPT-5	38 27.50	39 43.77
CPT-6	38 01.75	39 24.87
CPT-7	37 36.64	39 06.07
CPT-8	37 10.97	38 47.22
CPT-9	36 45.65	38 28.60
CPT-10	36 20.39	38 09.81
CPT-11	35 53.45	37 54.80
CPT-12	35 24.32	37 52.63
CPT-13	34 54.97	37 52.87
CPT-14	34 31.60	38 10.71
CPT-15	34 36.38	38 38.27
CPT-16	34 01.30	38 20.05
CPT-17	33 45.44	38 17.93
CPT-18	33 05.18	37 52.44
CPT-19	32 15.66	37 52.76
CPT-20	31 26.92	37 53.28
CPT-21	31 07.03	38 41.52
CPT-22	23 54.95	41 37.92
CPT-23	23 25.41	41 37.83
CPT-24	22 56.01	41 37.98
CPT-25	22 26.52	41 38.11
CPT-26	21 47.24	41 38.57
CPT-27	21 17.57	41 37.94
CPT-28	20 48.30	41 38.09
CPT-29	20 18.73	41 38.32
CPT-30	19 49.33	41 38.63
CPT-31	19 19.90	41 38.68
CPT-32	18 50.03	41 37.34
CPT-33	18 21.08	41 37.15
CPT-34	17 51.73	41 37.16
CPT-35	17 22.34	41 37.15

Figure 2.3. Plan View of CPTs 22 through 35 - Yolo Bypass
[USGS QUADS: Saxon (N), Liberty Island (S)]

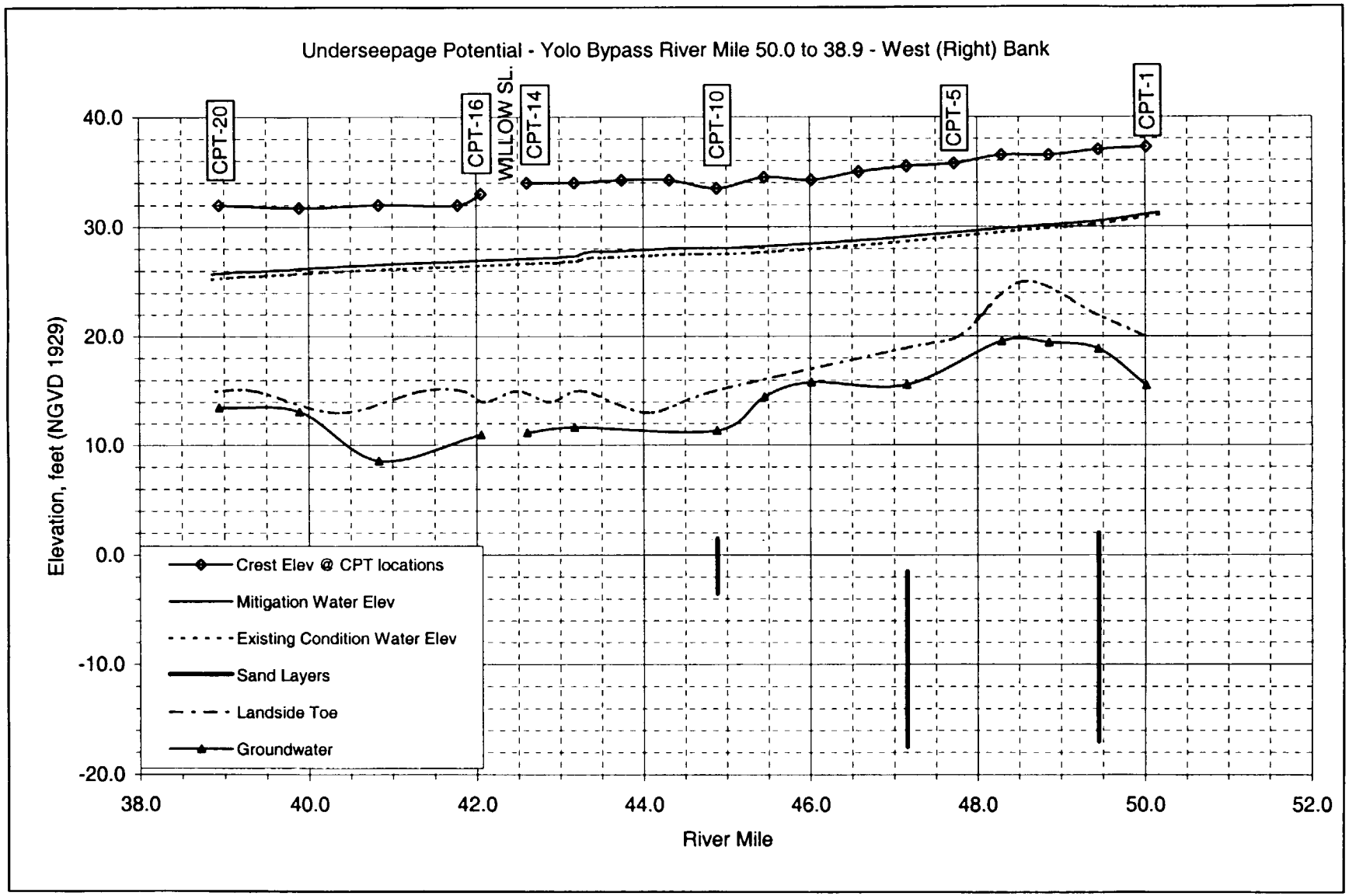


Figure 2.4 Yolo Bypass Underseepage Potential – Right Bank River Miles 50 to 38.9

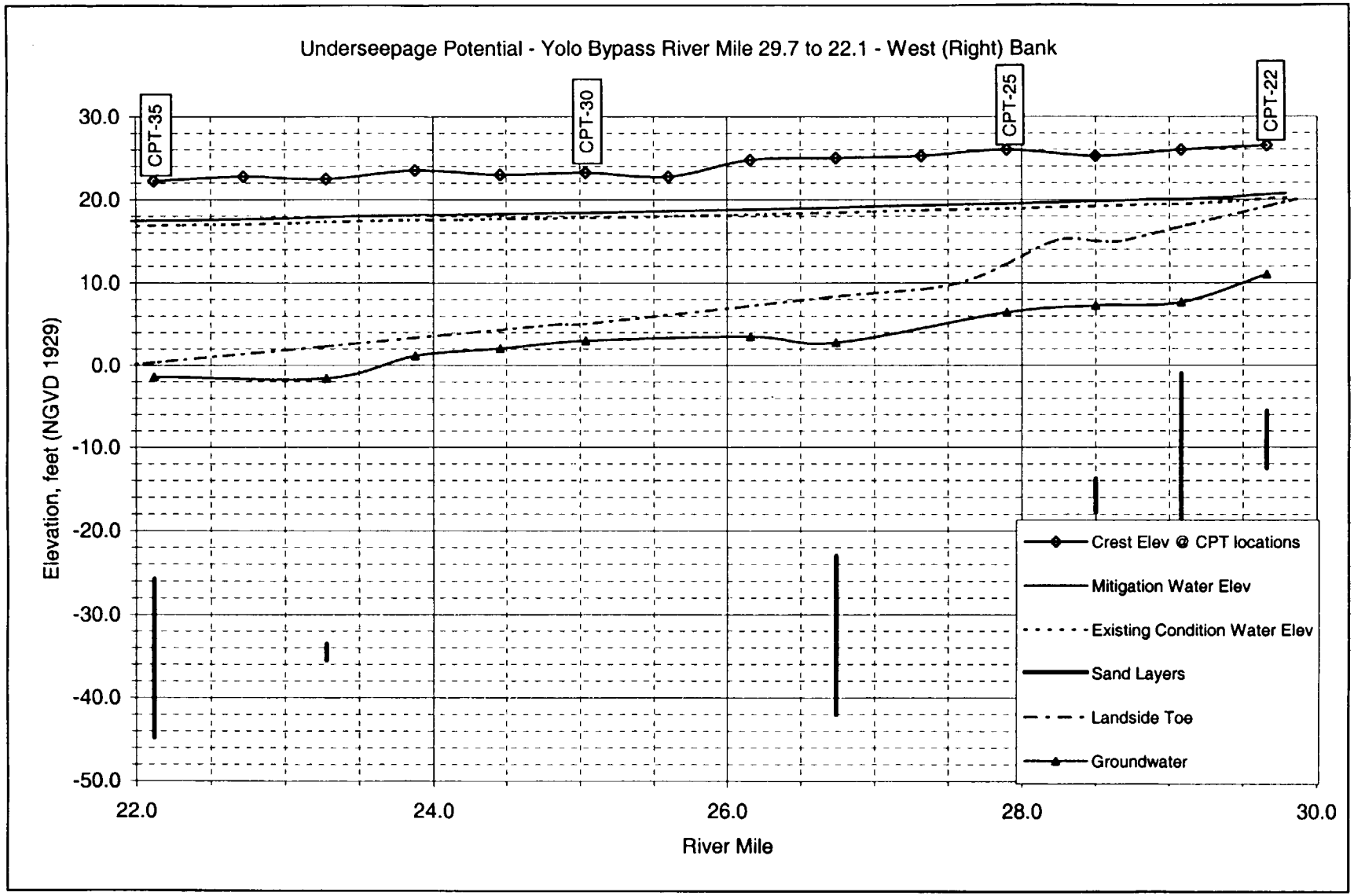
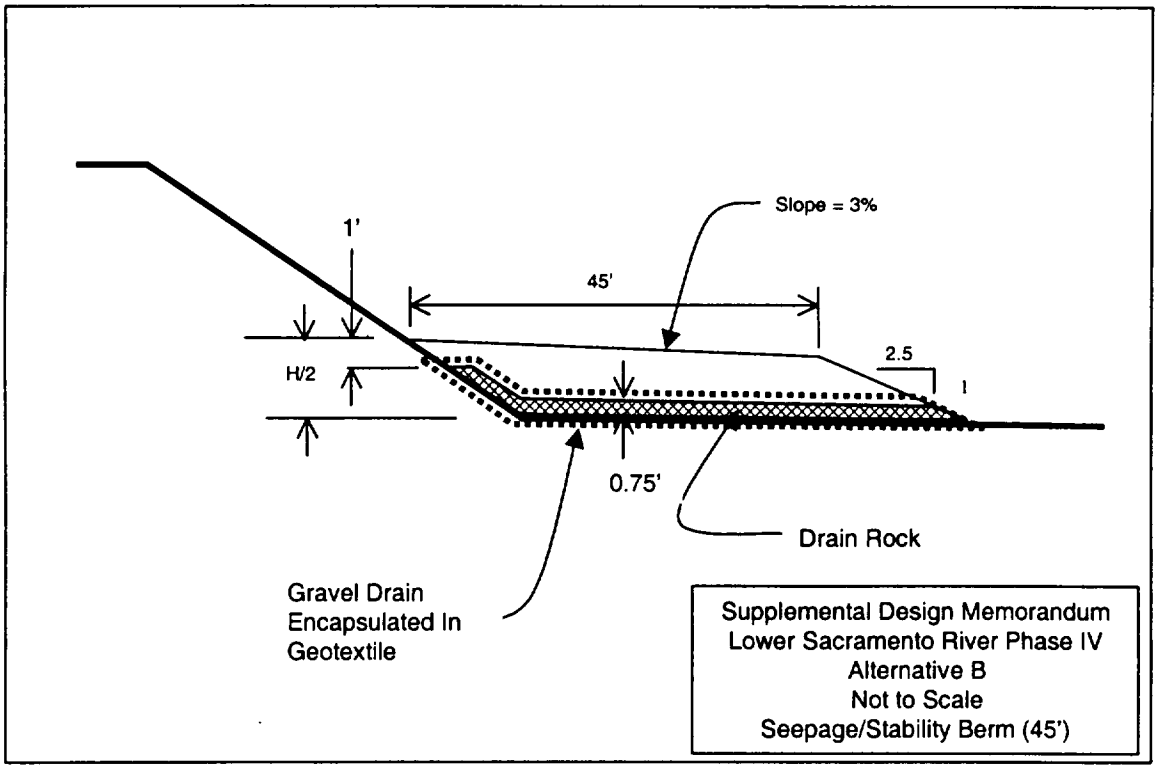


Figure 2.5 Yolo Bypass Underseepage Potential – Right Bank River Miles 29.7 to 22.1



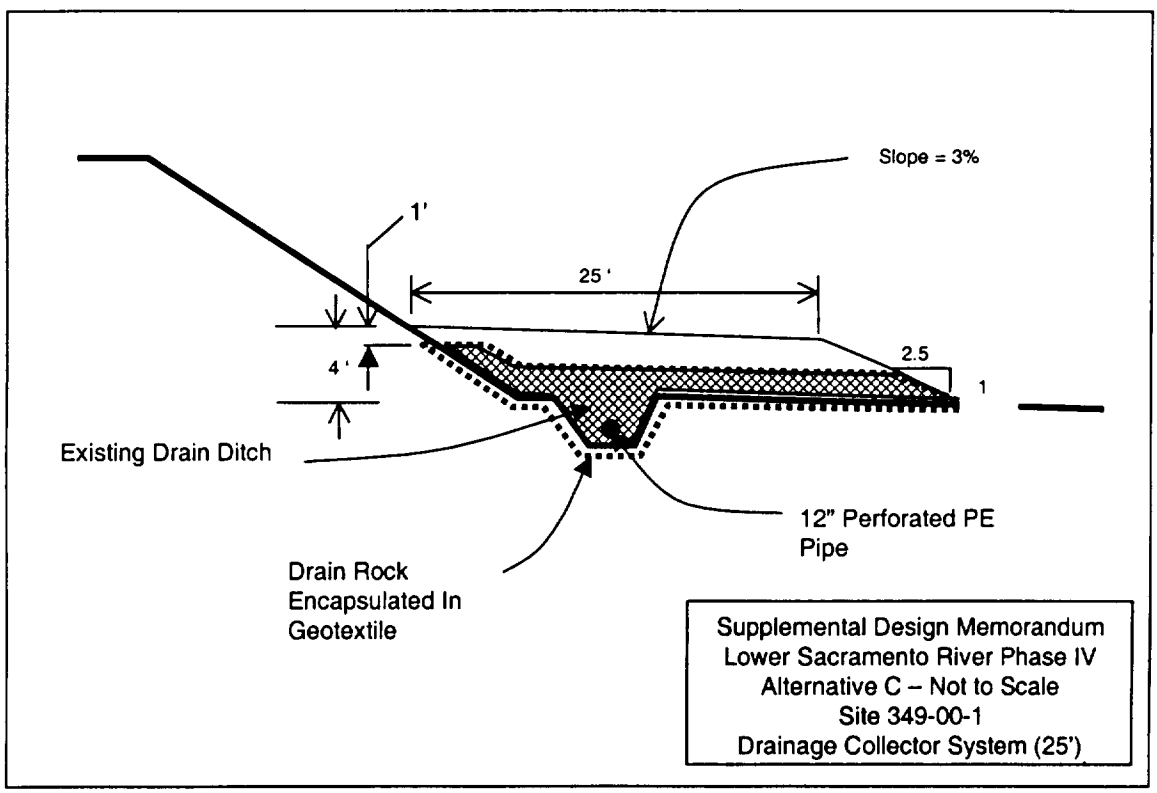
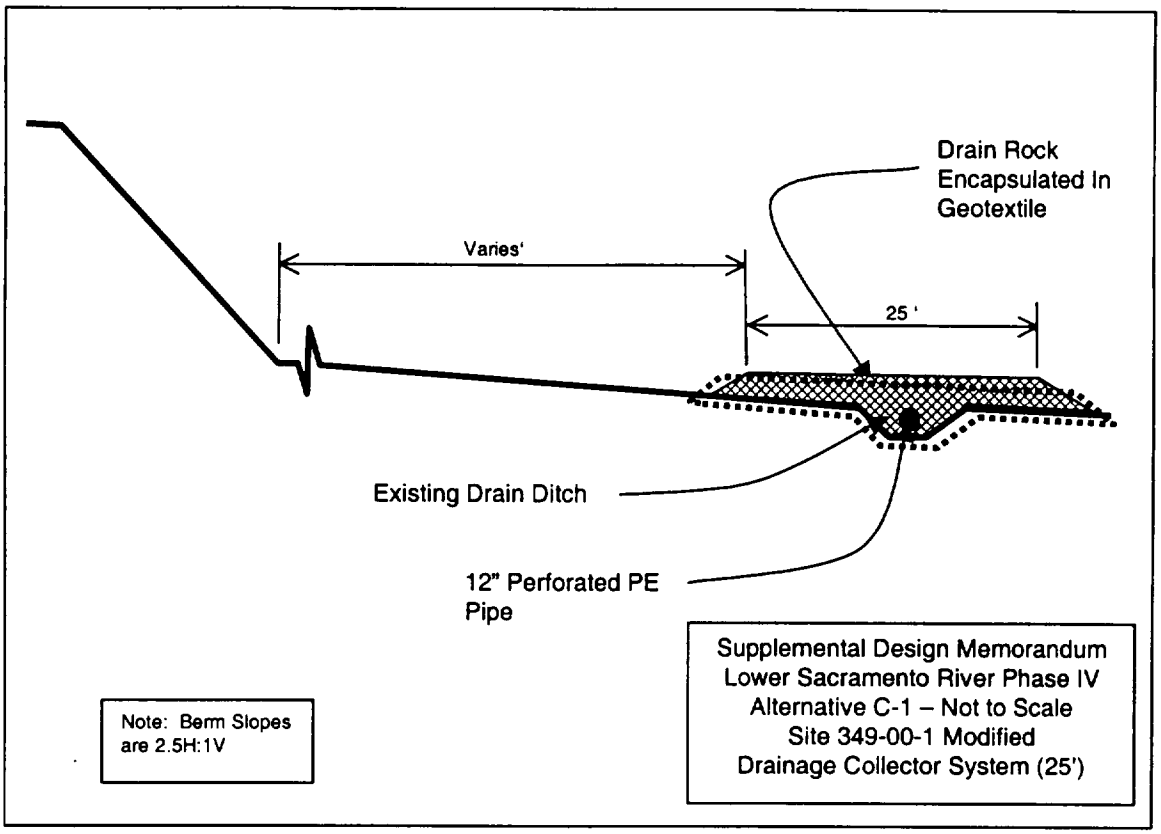


Figure 2.6. Levee Improvement Alternatives



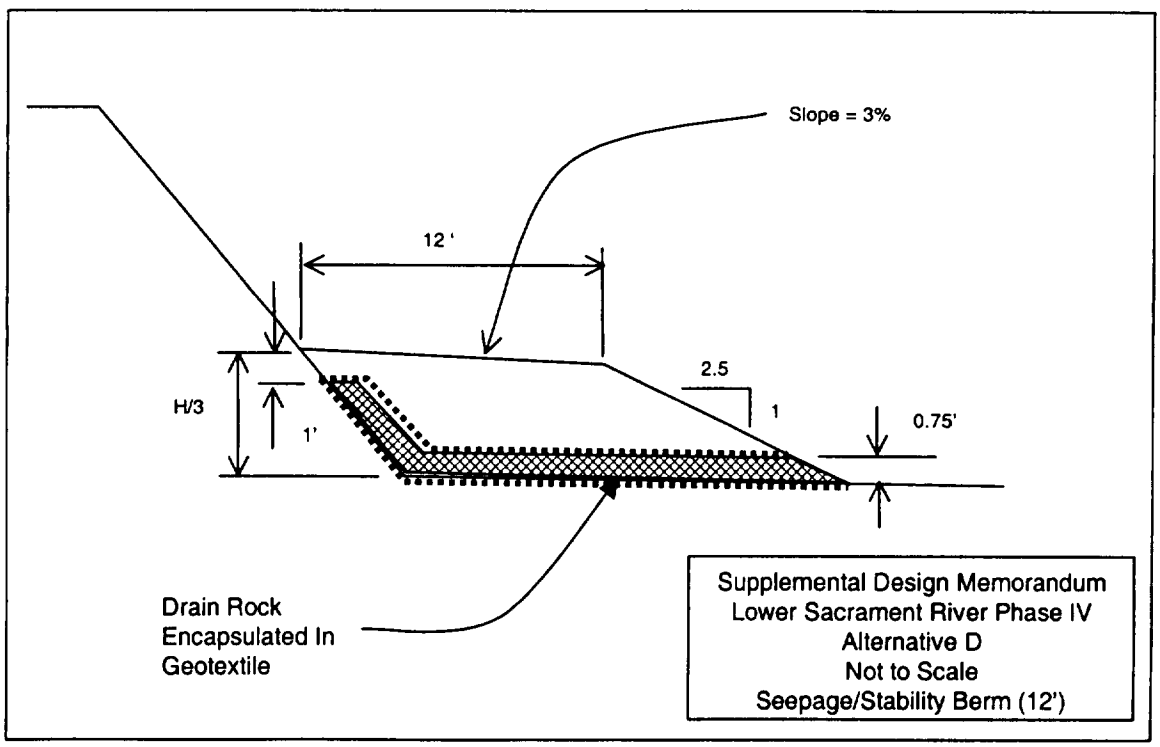


Figure 2.7. Levee Improvement Alternatives

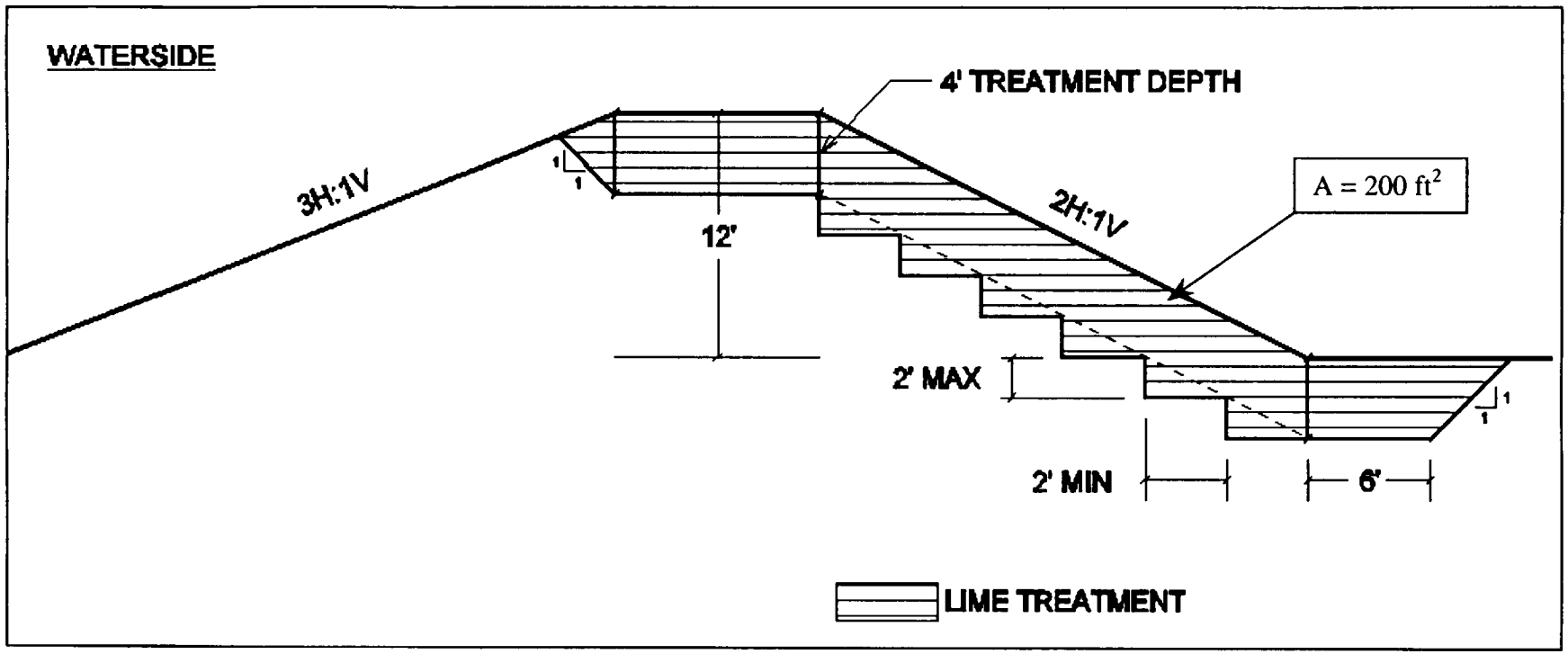


Figure 2.8 Typical Levee Cross Section with Lime Treatment